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Agricultural Memorandum No 566

International Hop Trials - 1968-1972. L P Smith.

Previous work had suggested an optimum mean temperature during the last 30-40 days prior to harvest for the highest alpha-acid content of hops.

The 1968-72 data from six European countries showed that the critical period was between the date of coming into hop and the date of picking. The dates of coming into burr and date of ripeness appeared to be less significant.

Critical temperature optimum had been suggested as lying between 16 and 17°C. This was confirmed by the latest results:-

Highest alpha-acids (Czechoslovakia 1968)	Fuggle	7.2%	16.7°C
	Northern Brewer	12.1%	16.8°C
	Hallertau	5.5%	16.5°C
	Saaz	6.8%	16.7°C

From the recent evidence it also appears possible that sunshine may affect quality. Above the temperature optimum, the previous data had shown a slow decrease with increasing temperature; this is associated with increasing sunshine.

Total correlation coefficients are:

	Fuggle	N. Brewer	Hallertau	Saaz
on temperature	-0.36	-0.47	-0.70	-0.65
on sunshine	-0.83	-0.70	-0.67	-0.72

and the corresponding partial correlations:

on temperature	0.04	-0.29	-0.49	-0.53
on sunshine	-0.80	-0.64	-0.43	-0.63

This suggests that sunshine is more significant than temperature in the range above the optimum for the varieties Fuggle and Northern Brewer.

To verify this the sunshine hours will have to be converted into radiation estimates as there is a wide variety in latitude in the trial sites.

Below the temperature optimum, the total correlation coefficients are:-

	Fuggle	N. Brewer	Hallertau	Saaz
on temperature	+0.82	+0.65	+0.48	+0.67
on sunshine	-0.72	-0.75	-0.58	-0.37

and the partial correlations:

on temperature	+0.73	+0.36	+0.19	+0.68
on sunshine	-0.56	-0.58	-0.41	-0.40

FH The full data are given in the Appendix.

Appendix

Fuggle

(a.) Temperatures at optimum and above:

Country & Year		Alpha-acid (%)	Critical Period	Mean Temp (°C)	Mean Sunshine (hrs/day)
Czechoslovakia	1968	7.2	Aug 8–31	16.7	4.4
"	1972	5.8	Aug 2–30	17.4	5.8
France	1968	5.7	July 28–Sept 5	17.1	5.9
"	1970	5.5	Aug 2–Sept 2	18.9	6.2
Yugoslavia	1968	5.2	July 22–Aug 20	17.7	6.6
Czechoslovakia	1971	5.1	Aug 1–31	18.4	6.9
Germany	1969	4.8	July 31–Aug 29	16.8	6.9
France	1969	4.8	Aug 1–Sept 9	18.2	6.2
Yugoslavia	1969	4.8	June 30–Aug 18	20.7	8.4
"	1972	4.7	July 19–Aug 21	21.3	6.2
"	1971	4.3	July 20–Aug 28	21.2	7.4
France	1972	3.7	July 27–Sept 6	17.3	6.9
"	1971	3.2	July 20–Sept 13	18.5	8.6

(Note: the Yugoslavia 1969 date of coming into hop is outstandingly early).

Best regression (0.83)

$$9.73 - 0.76\ S + 0.02\ T$$

(b.) Temperatures below optimum

Germany	1968	5.7	July 31–Sept 5	16.1	4.8
England	1968	4.6	Aug 15–Sept 5	16.1	5.9
"	1969	4.6	Aug 11–Sept 5	15.5	4.6
"	1971	4.5	Aug 14–Sept 10	16.2	5.9
"	1970	4.4	Aug 7–Sept 3	16.1	6.7
Czechoslovakia	1969	4.0	Aug 2–Sept 1	16.1	5.3
England	1972	3.6	Aug 16–Sept 6	14.5	6.4
Denmark	1972	2.7	Aug 20–Sept 21	13.2	7.0

Best regression (0.88)

$$0.49\ T - 0.38\ S - 1.1$$

Northern Brewer

(a.) Temperatures at optimum and above:

Country & Year		Alpha-acid (%)	Critical Period	Mean Temp (°C)	Mean Sunshine (hrs/day)
Czechoslovakia	1968	12.1	Aug 2-31	16.8	4.4
France	1968	10.7	July 24-Sept 5	17.0	6.2
Czechoslovakia	1972	10.6	July 27-Aug 30	17.9	5.9
Germany	1969	10.2	July 15-Aug 29	18.0	7.7
Yugoslavia	1968	9.6	July 18-Aug 20	18.0	6.9
"	1972	9.1	July 16-Aug 21	21.3	6.1
Czechoslovakia	1971	8.8	July 29-Aug 31	18.5	7.2
France	1970	8.8	July 29-Sept 2	19.1	6.5
Yugoslavia	1969	8.1	June 25-Aug 13	19.9	8.5
France	1969	8.0	July 27-Sept 3	19.1	6.6
Yugoslavia	1971	7.6	July 10-Aug 28	21.1	7.3
France	1964	6.4	July 23-Sept 6	17.4	6.9
"	1971	5.8	July 13-Sept 6	19.2	8.4

Best regression (0.73)

$$20.9 - 0.28T - 1.0S$$

(b.) Temperatures below optimum

Germany	1968	9.8	July 22-Sept 4	15.8	5.2
England	1971	8.1	Aug 9-Sept 15	15.6	5.9
"	1969	7.5	Aug 4-Sept 11	16.0	5.5
Czechoslovakia	1969	7.3	July 31-Sept 1	16.4	5.5
England	1972	7.1	Aug 16-Sept 11	14.3	6.0
"	1970	6.4	July 31-Sept 7	16.4	6.4
"	1968	6.4	Aug 8-Sept 18	15.6	5.1
Denmark	1972	3.2	Aug 18-Sept 21	13.2	7.0

Best regression (0.78)

$$8.7 + 0.51T - 1.64\ S$$

Hallertau

(a.) Temperatures at optimum and above:

Country & Year		Alpha-acid (%)	Critical Period	Mean Temp (°C)	Mean Sunshine (hrs/day)
Czechoslovakia	1968	5.5	Aug 6-31	16.5	4.4
France	1968	5.3	July 28-Sept 5	17.1	5.8
Czechoslovakia	1971	4.7	July 31-Aug 31	18.4	7.0
"	1972	4.6	Aug 3-30	17.4	5.8
Germany	1969	4.5	July 21-Aug 29	18.3	7.5
Yugoslavia	1968	4.4	July 13-Aug 19	18.6	7.5
France	1970	4.0	July 27-Aug 30	19.3	6.7
"	1969	3.8	July 24-Sept 3	19.2	6.5
Yugoslavia	1972	3.2	July 15-Aug 20	21.4	6.1
"	1969	3.3	June 30-Aug 13	20.6	8.7
France	1971	3.0	July 9-Aug 30	19.8	8.5
Yugoslavia	1971	2.9	July 12-Aug 17	21.2	7.9
France	1972	2.8	July 29-Sept 5	17.3	6.9

Best regression (0.77)

$$10.94 - 0.26\ T - 0.29\ S$$

(b.) Temperatures below optimum:

Germany	1968	5.2	July 24-Sept 5	15.9	5.1
England	1969	4.2	Aug 4-Sept 9	16.1	5.5
"	1971	3.7	Aug 5-Sept 9	16.3	5.7
"	1970	3.6	July 29-Sept 3	16.4	6.6
Czechoslovakia	1969	3.6	Aug 3-Sept 12	15.5	5.1
England	1968	3.2	Aug 15-Sept 16	15.7	5.6
Denmark	1972	3.2	Aug 18-Sept 21	13.2	7.1
England	1972	3.1	Aug 9-Sept 6	14.5	6.2

Best regression (0.62)

$$4.44 + 0.12\ T - 0.45\ S$$

Saaz

(a.) Temperatures at optimum and above:

Country & Year		Alpha-acid (%)	Critical Period	Mean Temp (oC)	Mean Sunshine (hrs/day)
Czechoslovakia	1968	6.8	July 31-Aug 31	16.7	4.4
"	1971	4.9	July 26-Aug 31	18.5	7.5
Germany	1969	4.7	July 16-Aug 29	18.1	7.8
France	1968	4.6	Aug 5-Sept 5	17.1	5.7
"	1970	4.1	July 9-Aug 30	18.7	7.1
Czechoslovakia	1972	3.9	July 26-Aug 30	17.9	5.9
France	1969	3.8	July 5-Sept 3	19.1	7.1
Yugoslavia	1972	3.5	July 10-Aug 20	21.4	5.9
"	1968	3.4	July 10-Aug 19	19.0	7.6
France	1972	3.1	July 15-Sept 5	17.7	7.1
Yugoslavia	1971	3.0	July 8-Aug 17	20.9	7.8
France	1971	2.7	June 19-Aug 30	19.0	8.8
Yugoslavia	1969	2.5	June 20-July 31	20.1	8.5

Best regression (0.81)

$$13.8\,5 - 0.34\,T - 0.50\,S$$

(b.) Temperatures below optimum:

Czechoslovakia	1969	4.8	July 30-Sept 1	16.5	5.6
Germany	1968	4.6	July 18-Sept 5	15.7	5.3
England	1969	4.5	Aug 4-Sept 9	16.0	5.5
"	1970	4.0	July 31-Sept 4	16.4	6.5
"	1968	3.3	Aug 15-Sept 20	15.5	5.4
"	1971	3.3	Aug 5-Sept 8	16.3	5.6
"	1972	2.6	Aug 16-Sept 7	14.5	6.2

Best regression (0.75)

$$0.76\,T - 0.55\,S - 4.95$$

Any comments or suggestions on this paper should be referred to the author.

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